

Mariner Venus-Mercury 1973 Mission Support

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During January and February 1974, DSN preparations for the Mariner Venus/Mercury 1973 Venus encounter were completed, and the encounter was supported in a near flawless manner. In addition, this period saw the continuation of spacecraft problems which required the Deep Space Network to respond with additional implementation and new operational techniques to facilitate achievement of mission objectives.

I. Planning Activities

During January 1974, DSN operations planning gave priority to preparations for the second trajectory correction maneuver (TCM) and for Venus encounter. However, in addition, a significant level of effort was required of the DSN Support Team to generate real-time operations plans in response to spacecraft problems. These problems and responses are discussed in *Section IV*, "Operations Summary."

Preparations for TCM No. 2 were well underway in early January 1974 for a mid-January burn. However, the occurrence of a spacecraft emergency on Jan. 8, 1974, involving spacecraft switch to the backup power chain, interrupted and delayed completion of the maneuver sequence. The TCM was rescheduled for Jan. 19, 1974 and then again slipped to Jan. 21, 1974 as additional spacecraft power constraints were factored in. These

changes required the DSN to make corresponding adjustments to DSN schedules, sequences, and staffing. During one particular week, sixty-eight real-time schedule changes were required to realign network support for MVM73, Pioneer 10 and 11, and radio science.

In parallel with TCM activities, the DSN planned a series of comprehensive Venus encounter readiness tests. These test procedures included Class I countdown exercises, appropriate portions of DSS system performance tests, critical requirements of the Venus encounter sequence of events, and use of the spacecraft as a data source. DSSs 14, 43, and 63 were scheduled for participation during the period of Jan. 17-30, 1974.

Following completion of TCM No. 2 activities, primary attention was again given to finalizing the sequence of events and configuration strategies for Venus encounter. However, this effort was complicated by the spacecraft

roll gyro oscillation-attitude gas consumption problem which occurred during the roll calibration maneuver on Jan. 28, 1974. In addition, a high level of effort went into the S/X-band radio science occultation portion of the sequence to assure feasibility of the demanding, rapid radio-frequency (RF) signal acquisition at exit occultation. Consequently, tweaking of the detailed DSN sequence continued until Venus encounter minus one day.

II. Program Control

Weekly status meetings with the Project continued throughout this reporting period. Open implementation items and problem areas were tracked until appropriate closures were accomplished. Weekly teletype status reports to NASA Headquarters and monthly inputs to the Project Management Report continued.

In late January 1974, the DSN conducted a Venus encounter readiness review to evaluate the final status of preparations and potential problem areas. The review and results of encounter readiness tests demonstrated that the DSN was in a high state of readiness for the critical operations.

III. Implementation Activities

A. Deep Space Stations

The previous Progress Report listed post-launch, open implementation tasks, and problem areas. Successful closure of most of these items was accomplished in January 1974 as described in this section. In addition, the DSN accomplished certain emergency implementation to accommodate changes in the spacecraft RF link characteristics.

1. Antenna microwave subsystem. The listen-only, low-noise ultracone was installed at DSS 43 without difficulty on the planned mid-January schedule. Excellent performance was demonstrated in follow-up tests. Tests will continue through March 1974 to demonstrate adequate performance for reception of 117-kbits/s video data under expected marginal RF link conditions at Mercury encounter on Mar. 29, 1974.

By mid-February 1974, the spacecraft high gain antenna problem had produced an RF downlink which was 6 dB less than normal, and an antenna pattern which was nearly completely linear rather than circular. About 3 dB of this loss was attributed to cross polarization between

circular polarization of the DSS antenna and the now linear polarization of the spacecraft. In response to Project request and to meet Mercury TV experiment objectives, the DSN took emergency action in February to provide, ship, and install linear polarization equipment at each of the three 64-m DSSs. This work is expected to be completed shortly before Mercury encounter.

2. Telemetry and command data subsystem. Accomplishment of capabilities in January 1974 for post-track recall of digitally recorded radio metric data marked the end of all required implementation in this subsystem. An existing Telemetry and Command Data Subsystem (TCD) software program was modified and integrated into the DSN to perform this function.

However, continuing engineering support was required to help analyze a problem observed in DSS 43's and 63's Original Data Records (ODRs) containing 117-kbits/s video data from Venus encounter. Essentially all of the video data were recorded on the ODR, but the data were not in the correct time ordered sequence. "Old" and "new" data were interleaved in a repetitive pattern requiring special processing by the Mission Control and Computing Center (MCCC) to recover video frames. Special tests are being planned and will be conducted at DSS 14 and CTA 21 to resolve this problem prior to Mercury encounter. However, the problem is observed only at the 117-kb/s rate which will not be used at Mercury encounter if the spacecraft antenna performance remains 6 dB below normal.

3. Tracking data handling subsystem (TDH). Implementation of planetary ranging capabilities was completed at DSSs 43 and 63 in mid-January 1974 approximately two weeks later than planned. Although declared operational on the basis of successful system performance tests, DSS 63 ranging data have exhibited a timing bias which makes it difficult to use for navigation purposes. These capabilities came none too soon. Near simultaneous ranging data were required from DSSs 12, 14, 43, and 63 for critical orbit determination exercises to rapidly re-determine the orbit following perturbations from the gyro-attitude gas usage problem.

4. Digital instrumentation subsystem. Update of the Digital Instrumentation Subsystem (DIS) software program was completed and integrated into the DSS in January 1974 as planned. This update provided the required Venus encounter capability for real-time handling of 10 samples/s doppler data via high-speed data lines.

5. *Pre/post detection recording subsystem.* Work continued on DSS 14's dedicated open-loop analog recording assemblies until two days prior to Venus encounter to achieve configuration and performance desired by radio science experimenters. Late modifications were required to adequately integrate both S- and X-band signals from the R&D Block IV receiver assemblies.

Also, quality checks of analog recording produced on the DSS standard analog recorder indicated improvements were needed to facilitate proper recording and recovery of telemetry data from this backup ODR. Tests at CTA 21 demonstrated that significant changes were required in channel assignments to achieve desired results. To avoid unacceptable risks of late configuration changes, this modification was only partially implemented prior to Venus encounter and then was completed thereafter.

6. *S/X-band equipment.* X-band doppler cycle slips and offsets described in the previous article continued to be periodically observed throughout this reporting period. Interface cable replacements and assembly adjustments in January 1974 did, temporarily, eliminate these problems during the Venus encounter period. By mid-February 1974, the problems were back again. Therefore, the DSN initiated a special coordinated team effort between DSN engineering, operations, and Project radio science experimenters to troubleshoot and achieve required performance prior to Mercury encounter. Noise interference appears to be the major cause, but its source is unknown at this time.

In early January 1974, the Command Modulator Assembly Switch required to provide Block IV exciter uplink capabilities was installed at DSS 14 but failed to operate properly due to a wiring logic error. The switch was removed for rework. Since stability of the Block III exciter was sufficient to meet S/X-band requirements at Venus encounter, it was decided that the switch would be reinstalled during the week of Feb. 24, 1974 in preparation for Mercury encounter support. This installation was accomplished as planned. Post-installation tests and operational use demonstrated proper performance with the Block III configuration. However, due to interface signal errors, switch performance in the Block IV configuration was not acceptable. Work on this problem continues.

B. DSN Ground Communications

Appropriate modifications and adjustments to the DSS 14/DSS 12 microwave link were initiated as a means of providing access to DSS 12's telemetry strings for

backup to DSS 14's two-string configuration. The planned use of this microwave link is for transmission of 2450 bits/s telemetry data to DSS 12 in the event DSS 14 loses one string while supporting dual subcarrier operations.

The microwave link between DSS 63 and DSS 62 was reactivated and adjusted to support real-time transmission of low rate telemetry data from DSS 63 to DSS 62. This capability permitted continuation of the DSS 63 communications terminal relocation/reconfiguration without interrupting data flow to project users. This work was satisfactorily completed on Feb. 28, 1974.

IV. Operations Summary

Following is a brief summary of DSN operations activities for January and February 1974. Primary attention is given to certain spacecraft problems which placed an unplanned, heavy load on the DSN in terms of revised plans, sequences, tests, schedules, and new implementation.

During this period, Mariner 10 coverage continued to be provided by a combination of 26- and 64-m subnet DSSs. January 1974 saw a rather equal sharing of the 64-m subnet between Pioneer and Mariner. DSN readiness tests for Venus encounter were satisfactorily completed between January 17 and 30, 1974. Beginning Feb. 1, 1974, DSS 14, 43, and 63 configurations were frozen for Venus encounter operations. DSN support continued to be very satisfactory, with exceptional performance demonstrated during the critical Venus sequence and during a number of spacecraft problems.

The spacecraft high-gain antenna went through a number of fail-heal-fail cycles during this period. Degradation finally stabilized at a downlink loss of 6 dB and a linear polarization rather than circular. This problem made performance of the link marginal for 26-m subnet reception of 2450 bits/s telemetry at a bit error rate of 1 in 10^4 or less. Furthermore, even 22 kbits/s video data would have been marginal via 64-m DSS at Mercury encounter. In response, the DSN performed frequent precision signal level measurements, conducted ellipticity measurements, and implemented linear polarization tracking capability in the 64-meter subnet.

Spacecraft roll gyro oscillations caused periodic high usage of attitude control gas. This perturbed the well-

defined trajectory requiring rapid generation of additional amounts of accurate radio metric data in the DSN. In response, the DSN negotiated with the Pioneer Project for additional 64-m coverage for Mariner 10 and scheduled a series of near-simultaneous ranging acquisitions.

Spacecraft power problems were varied but were primarily observed by the DSN in the form of power-on resets (PORs). PORs were frequent during roll calibrations and gyro turn ons. These cause the spacecraft to automatically switch, without warning, to a different data mode and to the interplex configuration. To minimize response time and data loss when PORs occurred, the DSN developed special procedures for subcarrier demodulator configurations, phasing, notch filter installation, and for analog record handling.

Flight and ground tests showed that the spacecraft auxiliary oscillator had a frequent one-half cycle offset when in the one-way mode. This instability would have masked Venus atmospheric effects on the RF signal severely degrading radio science occultation results. Proper auxiliary oscillator performance was obtained in the two-way mode but required use of the DSS 14 100-kW transmitter to gain adequate link performance. The two-way, 100-kW sequence had to be planned between Feb. 1, 1974 and Venus encounter on Feb. 5, 1974.

These problems caused delays of certain critical mission events such as trajectory correction maneuvers, calibrations and spacecraft computer updates. DSN operations was hard pressed to accommodate these changes in plans, schedules, and ground command activities.